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FINAL STATUS REPORT

CREEP BEHAVIOR OF METALS IN LOW-STRAIN REGION UNDER SLIGHTLY VARYING STRESSES

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1. SUMMARY

This report presents, in abstract form, results of the subject program at the conclusion of a period of fifteen months during which the program was supported by NASA Research Grant NGR-52-012-002. The analytical objectives of the program were substantially attained. Results of the experimental program were satisfactory and of interest. However the test series was not as extensive as originally planned, for reasons presented below. The status of publication of results is also presented.

2. ANALYSIS

The method of approach used for the development of relations to describe material creep behavior in tension after a change in stress was an extension of the linear viscoelastic method described in Ref. 1 for incremental changes in axial stress. The method of Ref. 1 was shown in the present program to be equally applicable for both positive and negative stress increments when creep recovery, occurring in the latter case, is disregarded. The recovery time appeared to be a logarithmic function of stress decrement (Ref. 2). Values of material parameters were obtained from data generated in the experimental program. At large increments of stress, whose effect on creep strain would not be expected to be linear, the various equations are easily adaptable by substitution of a stress function for the stress itself into the equations. Hyperbolic functions of stress increment such as suggested in Refs. 3 or 4 seem most reasonable; however this is yet to be verified experimentally.

Solutions were developed for tensile creep following an incremental bending load. The analysis made use of the relations determined for incremental changes in axial stress, including the effect of creep recovery on the concave side of the tensile creep specimen. Calculations involved stress redistribution, so that the strain distribution across the specimen remained linear, and iterative force and bending moment procedures. The solutions were programed for the digital computer, and computations are now being carried out for two types of bending problems. These are a tensile specimen of uniform cross-section, a) subjected to an incremental pure bending moment, and b) clamped at both ends and subjected to a small concentrated lateral force at an arbitrary point along its length. Experimental verification of computed results is planned for the coming year.

3. TEST PROGRAM

Progress in the experimental portion of the program has been reported previously in Refs.2 and 5. Creep tests carried out were performed primarily on commercially pure aluminum sheet material. The greater part of the tests were carried out at a temperature of 200°C (392°F), although some tests were performed at higher temperatures.

The tests involved creep under tensile stress followed by a positive or negative incremental change in the stress. In the range of stress increment applied (up to 6% of initial stress) the effect on creep behavior appeared to be linear (Ref. 2) in stress increment. Measurements of resonant frequency made during the tests showed that, as expected, the dynamic modulus of the material was not affected by creep. Resonant frequencies were determined in the first, second, third, fourth and fifth natural modes of vibration. The effect of creep on static (so-called inelastic) modulus and on material damping was masked in early tests, because the tests were performed at stresses in the plastic range of the material, in order to limit the test duration to ten hours or less. Recent tests were therefore carried out at stresses near the proportional limit of the material with satisfactory results as regards static modulus and damping measurements.

The tests are continuing and it is expected that final results will appear in a forthcoming Technion Report within three months. However it should be noted that the tests at lower stresses require on the order of 150 hours per test, with the result that the number of tests performed is considerably less than originally planned. Curtailment of the test program is justified by the significant data being generated.

Similar creep tests on AU-4G1 alloy sheet (equivalent to 2024-T3), an aluminum alloy of importance for its high strength and creep resistance at elevated temperatures, will begin in the near future.

4. PUBLICATIONS

Besides the Semiannual Status Report (Ref. 5) an Interim Report was published entitled (Ref. 2), "Creep of Commercially Pure Aluminum in the Low Strain Region under Slightly Varying Stresses" (TAE Report No. 63, February 1967). As mentioned previously, a final report containing details of the results referred to herein will be published by the Technion in the fall.

5. REFERENCES

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